V.—*Reports on the Progress of Physiological Botany.* No. I.

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Recent researches into the origin and development of the Vegetable Embryo.

This "vexed question," on which botanists in general have of late years been unable to form a satisfactory opinion, so contradictory and well-balanced has been the evidence for the various hypotheses, appears now somewhat nearer to a decisive settlement, since within the last year we have had no less than four elaborate and comprehensive essays presented to us, detailing the whole series of changes which the ovule passes through, from the opening of the bud to the ripening of the seed. When the names of Amici and Von Mohl appear as the authors of two of these papers, it will be understood how important these new investigations are; and the fact of the agreement of all four *inter se*, excepting in some trivial points, and the possibility of reconciling their results with the *appearances* which have presented themselves to authors holding different views, will probably cause them to be regarded as tolerably conclusive. The great result at which all these recent writers have arrived is, that Schleiden's statement, that the end of the pollen-tube becomes the embryo, is incorrect, and that the old opinion, which regarded the pollen as the source of a fertilizing matter necessary to stimulate the embryo-sac to the development of the germ of the future plant, is true; the pollen-tube being consequently merely the agent for the conveyance of the fertilizing matter through the style and the foramina of the ovule, having its progress arrested upon the outside of the wall of the embryo-sac, through which and the membrane of the pollen-tube itself the fecundating fluid is supposed to be imbibed.

The few remarks which it may be necessary for the reporter to make on the relations of these investigations to preceding observations, will be most conveniently reserved till after a general account of them has been laid before the reader.

The first paper we meet with is one read by Prof. Amici before the Italian Congress at Genoa in 1846. Our knowledge of it is derived from German and French translations*.

In the first instance the author refers to some observations previously made public upon *Cucurbita Pepo*, in which he showed that the pollen-tube penetrates into the neck or summit of the nucleus to a certain depth, but *never* into the embryonal vesicle†,

* On the Fertilization of *Orchidaceæ*, by Prof. J. B. Amici, Giornale Botanico Italiano, di Filippo Parlatore. (Transl. Ann. des Sc. Nat. 3 sér. vii. 193, April 1847; and by Von Mohl, Bot. Zeitung, May 21 & 28, 1847.)

† By *embryonal vesicle* Prof. Amici signifies the embryo-sac, and this must

which pre-exists and is visible in the nucleus before the introduction of the pollen-tubes into the ovules. Probably the impregnation is effected by the passage of the fertilizing fluid through the membrane of the embryonal vesicle, this fluid being conducted to or deposited in the vicinity, or even on the surface of the latter. It is certain that the vesicle only acquires the power of development after the pollen-tubes have penetrated the coats of the ovule, and poured out the fluid which they contain upon it; it dies without having shown any signs of growth when it is not moistened by the fertilizing fluid.

The subsequent development of the embryonal vesicle shows itself first towards the base; that is, at the point opposite to where the pollen-tube acts. All trace of this tube has disappeared by the time the enlarged embryonal vesicle begins to multiply its cells; these become enlarged, particularly toward the base of the nucleus, finally reaching its walls, thus entirely filling its cavity, and even causing its rupture. The form which the embryonal vesicle ulteriorly assumes in the course of development is that of a constricted sac (the embryo-sac), within which, at the summit, many days after the epoch of fertilization, a greenish body makes its appearance, which is the true embryo of the new plant.

From these facts, which are constant, it follows that the pollen-tube is not transformed into the embryonal vesicle*, because the latter exists already in the unfecundated ovule: still less is the pollen-tube developed into the embryo, for the embryo is not produced till long after, when the vesicle, very much enlarged, has become the embryo-sac. Moreover, the embryo is visible long before its diameter is equal to that of a pollen-tube, so that this latter cannot have become converted into it.

"In reference to *Cucurbita Pepo* therefore," says Amici, "I could be certain that Schleiden's theory was incorrect, and, microscope in hand, offer direct demonstration. Analogy led me to believe that in other plants, where the action of pollen is necessary to fecundation, the opinion of the German botanist was inadmissible; and I was the more strengthened in this conclusion, that in my numerous earlier researches in other plants, I had never seen the pollen-tube either lodge itself in the embryonal vesicle when the latter existed before fertilization, or itself become the embryonal vesicle."

After stating that although he had not extended his observations to the families *Orchidaceæ* and *Asclepiadaceæ*, he was induced

not be confounded with the *germinal vesicle*, which is the first cell of the embryo.—*Rep.*

* There is some confusion in the translations here: in the French this is given *vésicule embryonnaire*; but Prof. Mohl uses the term *Keimbläschen* (germinal vesicle), with the synonym *vesichetta germinativa*.—*Rep.*

to presume, from his knowledge of the researches of MM. Brown and Ad. Brongniart, that there was no essential difference in the mode of fertilization in these families, M. Amici goes on to say that he considered new researches necessary to the confirmation of his conjectures, and this more than ever after the publication of the supplemental note of Mr. Brown, in which the "mucous tubes," instead of being regarded as pollen-tubes, were stated to be apparently distinct from them, although engendered or produced by their influence. If this last statement were incontestable, not only would Schleiden's theory be totally overturned, but Amici's idea, that the elongation and penetration of the pollen-tube into the coats of the ovule is a general law, would be devoid of ground.

The want of means and leisure had prevented the prosecution of his researches on this subject until the publication of Gasparini's observations on *Cytinus hypocystis* revived M. Amici's desire to determine these points, and he commenced a minute investigation of the organs of fructification of the *Orchidaceæ*. These have confirmed him in the earlier opinion of Mr. Brown, and he regards the strings of tubes descending into the ovary as really bundles of pollen-tubes. He has moreover been able to determine the precise state of the ovule before the arrival of the pollen-tube; then, how the latter penetrates the coats and behaves in relation to the embryonal vesicle; and lastly, observed the immediate changes which follow, in the ovule, the introduction of the pollen-tube. All these go to support his former observations, and exclude the idea of the conversion of the extremity of the pollen-tube into the embryo.

In the first place is offered the evidence on which he founds the opinion that the six bundles or cords of tubes descending into the ovary are prolonged pollen-tubes. Regarding the description of the appearance and course of these tubes, given by Mr. Brown, as altogether agreeing with the characters of pollen-tubes in other phanerogamous plants, it only remained to determine the identity of the pollen-tubes attached to their granules, and entangled in the thickness of the stigma, with the other tubes of a supposed different origin, and (hypothetically) produced in the immediate vicinity of the former; this identity was established several times by compressing the stigma between two glass plates, and observing that the tubes were continuous with each other. The slight peculiar characters proposed to be founded on the coagulations, &c. in the "mucous tubes," Amici considers valueless for distinguishing them from pollen-tubes; these coagulations, sometimes interruptions of the continuity of their cavities, being consequent on the gradual withering of the layers of the stigma and style, which interferes with the communication with the parts

above, and the upper part of the tubes thus remains destitute of granular matter or fertilizing fluid, because the latter is always carried toward their lower extremities. To the objection that the tubes are too numerous to be produced from the pollen-grains, the author opposes the fact of the enormous number of granules contained in the pollen-masses; for instance, in *Orchis Morio* the two principal pollen-masses contain each no less than 200 secondary masses; and the latter, which when compressed divide into granules united in fours, individually present more than 300 orifices from which pollen-tubes may be emitted; consequently in all no less than 120,000 tubes may be produced. Again, in *Orchis abortiva* the moistened point of a needle will take up several thousand of the simple spherical pollen-grains, and in this species the progress of the pollen-tubes along the conducting tissue of the female organ may be easily followed, affording conviction that the mucous cords are neither more nor less than prolongations of them.

With regard to changes of relative position of the parts of the ovule in the ovary occurring before the period of fertilization, the author does not consider it worth while in the present day to stop to discuss them, since it is known that in whatever direction the orifices of the coats of the ovule point, the ovules may be fertilized by filaments floating freely in the cavity of the ovary. He notices that M. Brongniart found instances of this in *Helianthemum niloticum* and *ægyptiacum*, without however recognizing the free filaments to be pollen-tubes; and he himself has seen similar filaments free in the ovary of *Cresta gialla**, which possesses no conducting tissue.

The first researches of Professor Amici on the *Orchidaceæ* were made on *Orchis Morio*. At the period when the corolla expands, the ovule is so far developed, that the testa, the tegmen and the nucleus, or the primine, secundine and nucleus, may be distinguished; the latter consists of a large central utricle inclosed in a layer of smaller cells; it resembles an acorn, the teguments representing the cupule.

Subsequently this cellular layer or membrane which clothes the nucleus opens like a tulip, and the nucleus, consisting of a simple cell, remains wholly uncovered, so that a granular fluid collected toward the apex may be seen in its interior. It might be supposed that this exposure of the nucleus indicates the fitting moment for fertilization, but this is yet far distant.

When the flower has begun to wither, a new transformation has taken place in the ovule. The testa and tegmen have in-

* *Cresta gialla* is translated Cockscomb, with a query, by Prof. Von Mohl. In the Ann. des Sc. Nat. it is considered as *Rhinanthus crista galli*. It seems most probable that *Celosia cristata* is the plant in question.—*Rep.*

creased in size; the tegmen still projects beyond the testa, but the nucleus is covered by both membranes, and has not perceptibly enlarged. But the granular fluid formerly collected at its upper extremity has become converted into a cell, which is the embryonal vesicle (*vesichetta embryonale*), and is filled with a similar fluid.

Another epoch succeeds the withering of the flower. The stigma (or stigmata, for there are three) show by their decay that they are dead. The pollen-mass has already acted upon them; the pollen-tubes, after having traversed their tissue and that of the style, have become prolonged into the evidently enlarged ovary. The ovule has equally undergone a change; the tegmen no longer projects beyond the testa; it is contained within it. The nucleus retains its relative situation within the tegmen, and the embryonal vesicle, which is always adherent to its upper end, exhibits the granular fluid, previously distributed throughout its cavity, collected toward its base. [Prof. Von Mohl, in his translation, here explains that the author, by the apex of the embryonal vesicle, signifies the end corresponding to the apex of the nucleus; and by the base, the end hanging free in the nucleus; an explanation rendered necessary by the anatropous condition of the ovule.] The ovule is now exactly in the condition to receive the influence of the pollen. The pollen-tube enters by the orifice of the testa, and its progress into the interior of this first coat is as visible as though no membrane intervened; its passage through the canal of the tegmen is not always so clear, for either from an actual narrowing of the canal, or from an optical illusion resulting from the cylindrical form of the cells of the tegmen which bound it, the diameter of the tube appears to be much diminished. But there can be no doubt of its prolongation when its extremity is clearly seen to pass out from the narrow canal of the tegmen and into the cavity of the nucleus. The question now is, does it push back the pre-existing embryonal vesicle in order to enter its cavity? To this Prof. Amici replies, most decidedly, no. The pollen-tube merely comes in contact with the side of the upper part of the embryonal vesicle, and remains adherent to it, finally withering and disappearing. The end of the pollen-tube, filled with a greenish and granular fluid, contrasts distinctly with the embryonal vesicle, which in the upper part, where it is in contact with the tube, is filled with a limpid fluid; while below, where the pollen-tube never reaches, it contains a white granular fluid. This condition of the circumstances, the author says, is so constant, that he can tell at a glance whether an ovule has been fertilized or not. Whenever the embryonal vesicle presented itself with the pollinic appendix just spoken of, he was certain of finding the tube engaged in the coats of the

ovule, while he never met with it when the appendix was wanting.

After fertilization, the granular white fluid contained in the embryonal vesicle becomes condensed, and appears evidently contained in a new cell, which shortly after subdivides into several others filled with granules; then these become extremely multiplied, and thus form the embryo which by degrees comes to occupy the whole of the cavity of the nucleus. At the same time, the other portion of the embryonal vesicle, that which was in contact with the pollen-tube, becomes elongated upward, dividing likewise into cells, but into cells which are transparent and situated one above another, so as to form a large confervoid filament; this traversing in the opposite direction the course followed by the pollen-tube, enlarges and passes through the orifices of the tegmen and testa, and becomes prolonged even into the interior of the placenta (observed in *Orchis mascula*).

The pollen-tube usually disappears during this period, but occasionally it may still be seen with its extremity *in situ*, even after the cells of the embryo have been multiplied. It is not rare to find it in this condition in *Orchis abortiva*, and the author has once observed it persistent even to the period when the reproductive body had filled the whole cavity of the nucleus.

Orchis abortiva is better adapted for these observations than *O. Morio*, and particularly for observing the introduction of the pollen-tube into the orifice of the tegmen, since in this species the state of the ovule at the epoch of fertilization is such that the testa only covers the lower half of the tegmen and nucleus. *O. maculata* appeared a less favourable subject than *O. Morio*, but it afforded proofs that the phænomena were identical in the two species. The author imagines that *O. pyramidalis* would offer great facilities for these researches, as the ovule appeared to him to be extraordinarily transparent; he was unable to follow its entire development, having only at hand a single withered specimen.

Prof. Amici states directly that he is unable to say what is the real action of the pollen-tube upon the ovule in impregnation. However he considers it probable, although it cannot be demonstrated, that the subtile fluid of the pollen-tube filtrates through the membranes into the interior of the embryonal vesicle, and that the mixture of the fluids of the male and female organs constitutes the organizable substance. It is also possible that the generative power resides in the membrane of the embryonal vesicle, and that the imbibition of the liquid brought by the pollen is necessary to set this power in action. Other explanations of the phænomena might be offered, the author says, but it is not his intention to give himself up to speculation, to lose himself in the field of hypotheses. He adds merely one fact,

namely, that in his numerous investigations he has never found more than one pollinic filament within the nucleus, although he has several times met with two embryonal vesicles, and consequently two embryos fertilized by a single tube.

Prof. Von Mohl* has published an account of his elaborate investigations on this subject made during the spring of 1847, his attention having been newly directed to it by the observations of Amici above-related. They agree almost perfectly with the latter, but considering the interest attaching to the inquiry, it may be as well to give an account of the points not fully described by Prof. Amici, and the slight discrepancies which exist between the accounts given by the two observers.

Prof. Von Mohl states that the pollen-tubes are easily distinguished from the cells of the conducting tissue of the style by their greater length and their much smaller diameter; that of the pollen-tubes being on an average $\frac{1}{180}$th of a millimetre, that of the cells of the tissue of the style $\frac{1}{60}$th; and he states that the "mucous tubes" of Mr. Brown are certainly the pollen-tubes.

About the fourth to the sixth day the ovary has become twice or thrice as large as at the time of the expansion of the flower; the ovule has become greatly inclined, and the coats of the ovule have grown, the inner some distance upward on the nucleus, the outer not so far as the inner. The nucleus has become enlarged upward in a clavate form; the embryo-sac is relatively much increased in size, so that the cells which form the outer layer of the nucleus are flattened, and form a comparatively thin investment to the embryo-sac which they inclose.

In about seven or eight days the ovule is perfectly anatropous; the inner coat has become much longer than the nucleus, and the outer coat attained a length about equal to the latter. The nucleus possesses essentially the same structure as before.

In this last observation there is a disagreement with Amici's, since he says that the outer layer of the nucleus opens by the separation of its cells, before the coats of the ovule grow over the nucleus. This Von Mohl could not detect; on the contrary, he perceived the outer cells forming an envelope to the embryo-sac up to the tenth or twelfth day. During this time the embryo-sac has become much enlarged, and its former polyhedral form changed into an ovate. Its cavity is no longer, as before, perfectly filled with protoplasm, but a space filled with watery fluid has formed in the midst, and the protoplasm principally accumulated at the two ends of the embryo-sac, particularly at the upper. The coats have by this time become very much larger in proportion to the nucleus; the inner projects a good way be-

* Ueber die Entwicklung des Embryo von *Orchis Morio*.—Botan. Zeit., July 2, 1847.

yond its apex; the border of its mouth is swollen into a kind of roll, and the canal leading from it to the nucleus has begun to diminish in diameter. The outer coat begins to elongate downward from the lower end of the ovule in the form of an obtuse hollow spur. The pollen-tubes have by this time reached the lower end of the placenta.

About the end of the second week the embryo-sac has wholly displaced the outer cellular layer of the upper and larger half of the nucleus. How this occurs the author could not clearly make out, and he leaves undetermined whether these cells are compressed gradually until their cavities are obliterated, and whether their membrane finally becomes blended with the embryo-sac or is absorbed. The outer coat now projects beyond the inner, and the canal of the latter becomes sensibly narrower, the mouth of the outer coat still continuing widely open. The pollen-tubes form a dense interlacement of curling filaments with knot-like swellings upon the placenta; their diameter is from $\frac{1}{113}$ to $\frac{1}{70}$ millim.

The external form of the ovule remains henceforward without much alteration, but a series of changes of the highest importance now ensues in the contents of the embryo-sac. The mass of protoplasm collected at the upper end, which hitherto appeared in the form of a simple deposit in the interior of the wall of the upper part of the cell, begins to separate into three masses, rounded below, connected together above. These masses are the first traces of the formation of three contiguous cells; the nucleoli of each of these cell-nuclei can be distinctly seen before any trace of their membrane is visible. No sharp line of demarcation between the nuclei themselves, or between them and the protoplasm, can originally be detected; this is either because the nucleus is subsequently formed by a firmer union of a portion of the protoplasm, or its substance differs so little from the surrounding protoplasm in optical qualities, that the line of division escapes the eye. The conversion of these masses of protoplasm into ovate cells, which become enlarged downward to reach about the middle of the embryo-sac, takes place rapidly; the author states that he has reason to assume that this change takes place, as a rule, in twenty-four hours. In proportion as these cells become elongated downward, the protoplasm contained within them, enveloping their nuclei and originally occupying their entire cavity, is drawn downward toward the lower end; that is, the end turned away from the apex of the nucleus.

This is the epoch when the pollen-tubes, which proceed from the placentas in a very tortuous manner, enter the mouth of the ovule, and now, Prof. Von Mohl says, "the more difficult part of the investigation begins." The pollen-tubes are easily followed

through the canal of the outer coat, but it is very difficult to trace them (as Amici also remarks) through the very narrow canal of the inner coat. The pollen-tubes must not only become diminished to a third or a fourth of their former diameter, but the refraction of the light in the cylindrical cells of the inner coat greatly interferes with distinct vision of its form. Some assistance is obtained by a very slight compression of the object, which is also necessary to expel air-bubbles which remain between the coats and in the canal of the inner coat, when the ovule is viewed in water; and a microscope of the sharpest defining power is very desirable. A magnifying power of 200 diameters suffices, if its lenses be perfectly corrected. The lower end of the pollen-tube reaches the rounded apex of the embryo-sac, and turns toward the side to run a short distance sideways upon it. This of course can only be seen when a side view is obtained; if the pollen-tube lies above or below the embryo-sac, as the observer looks down upon it, he may easily imagine that it is in the interior of the embryo-sac. The circumstance that the pollen-tube follows the curved surface of the embryo-sac well supports the conclusion that it lies upon the outer side of the latter, and runs between its membrane and the inner coat of the ovule. The lower end of the pollen-tube swells up considerably in a clavate form, and then projects, especially at a somewhat later period, a good way into the embryo-sac, probably on account of the pressure it experiences from the coat of the ovule. The next phænomenon is a change in the interior of the lower end of the pollen-tube and its inferior clavate expansion; they no longer contain, like the upper part of the pollen-tube, a clear fluid in which granules are intermixed, and which has not the most distant resemblance to a tissue on the eve of development, or a protoplasm destined to the production of cells; they now exhibit a coagulated, grumous mass, of a greenish-yellow colour. That this mass results from the transformation of the fluid contained in the pollen-tube is evident, from the fact that in certain cases the contents of that part of the pollen-tube outside the mouth of the ovule acquire a similar peculiarity. This coagulated condition of the contents of the lower end of the pollen-tube caused the author to feel doubtful at this stage of his inquiry as to the real point of origin of the embryo, since it seemed possible that this lower end of the pollen-tube was about to become developed into it.

One of the three cells lying at the upper end of the embryo-sac now begins to grow; in rare cases a second follows it in a similar development. The protoplasm of this cell is, as will be remembered, collected at the lower end; in a short time a transverse septum is formed; a second and two more quickly fol-

low, so that this cell (the germinal vesicle) is thus changed into an ovate body composed of three or four cells lying one above another. Of these secondary cells the two situated at the two rounded extremities are of greater diameter than those lying in the middle. Each of them contains a nucleus.

Contemporaneously with the growth and division of the germinal vesicle, the protoplasm collected at the base of the embryo-sac forms itself into an irregular mass of roundish parenchymatous cells, of which some frequently project into the central unoccupied space of the embryo-sac, and even come in contact with the lower end of the germinal body. In the course of the next two or three days the germinal body increases in size so much that it gradually comes to occupy the whole embryo-sac, displacing the cells contained in its lower end; its diameter is now about $\frac{1}{30}$th of a millimetre. At the same time a longitudinal septum is formed in the lowest cell of the germinal body, and soon after in the next above it.

The lower end of the pollen-tube, the swollen, blind extremity of which is about $\frac{1}{100}$ of a millimetre in diameter, undergoes no change during this time.

The lower cells produced by the division of the germinal vesicle grow faster than the upper, so that the form of the structure is changed from ovate to clavate, the larger end downward.

The cells of the upper end now grow upward and form transverse septa, finally passing out through the canals and the mouth of the ovule, as described by Amici, in the shape of a confervoid filament or articulated hair. Originally the end of the pollen-tube lies beside this, so that they cannot be mistaken one for the other. Simultaneously the cells of the lower end multiply and form an enlarged body, the cells of which are filled with a dense mass of granules; this opake cellular nucleus is of course the embryo. The hair-like prolongation of the upper end is distinguished both by its cylindrical form and the transparency of its cells, which merely contain watery fluid with a small quantity of finely granular protoplasm and a cell-nucleus. When the germinal vesicle has thus become developed into the embryo and its filamentous appendages, the pollen-tube disappears, apparently by absorption. At the time when the filamentous appendage becomes elongated, a deposit of spiral fibres occurs in the cells of the outer coat of the ovule, and the seed proceeds rapidly toward maturation.

Comparing these observations with Amici's, it will be seen that they only differ in one point of very small importance, which refers to the mode in which the embryo-sac displaces the nucleus. Prof. Von Mohl deduces from them the conclusion, "*that we must*

consider the pollen-grain, not as the ovule of the plant, but as its fertilizing organ; that Schleiden's theory of vegetable impregnation is false."

He considers these observations as a complete proof of this proposition, since he worked with such care and perseverance that he ventures to consider them incontestable. They refer to a single species alone, and this of a family possessing many peculiarities, but he believes that every one will agree with him in idea that the process of fecundation is essentially the same in all Phanerogamous plants, that is, in reference to the question whether the pollen-grain or the ovule produces the embryo—whatever modifications of the minor points may occur in different families. At the end of his memoir the author offers some speculations which have arisen out of the foregoing observations. He asks whether the three germinal vesicles which are formed in the upper end of the embryo-sac may not be identical in their nature with R. Brown's *corpuscula* in the *Coniferæ*: the chief difference between them appears to be, that in the *Orchidaceæ* the suspensor (the filamentous elongation) consists of a single row of cells and takes a backward course, breaking through the nucleus and growing out into the seed, the embryo remaining in its place; while in the *Coniferæ* the suspensor is composed of several rows of cells and breaks through the embryonal vesicle below, so that the growing embryo at its lower extremity attains its fuller development outside the embryonal vesicle*.

K. Müller† has followed the development of ovules in a number of plants; he gives a minute account of his observations on *Orchis Morio, Monotropa Hypopitys, Begonia cucullata* and *Elatine alsinoides*. He fully confirms the statements of Amici and Mohl with regard to *O. Morio*, the only point of difference being that he could never see the end of the pollen-tube filled with green matter as above described. Otherwise he traced the pollen-tube through the foramina of the coats and saw it lying on the side of the summit of the embryo-sac. His researches in *O. latifolia, paludosa, maculata, militaris, Platanthera bifolia* and *Ophrys ovata* yielded similar results. In all these the embryo was produced from the lower cell of the series produced from the germinal vesicle. In *Monotropa* the pollen-tube is applied directly to the apex of the embryo-sac, and the embryo is here

* It appears to me that this parallel is not well-grounded: have not the corpuscula of the *Coniferæ* rather the import of embryo-sacs, like those of *Viscum*, than of germinal vesicles? This is the opinion of Schleiden.—*Rep.*

† Beiträge zur Entwickelungsgeschichte des Pflanzen-embryo, von Karl Müller.—Botanische Zeitung, Oct. 15, 22 and 29, 1847.

developed out of the middle cells of the series, and thus presents two appendages at a certain stage.

Begonia cucullata offered a very favourable opportunity for the investigation, from the great transparency of the cells of the coats. Here Müller states that he is certain that the germinal vesicle is formed by a cytoblast in the cavity of the embryo-sac. In *Elatine alsinoides* the coats of the ovule are so much developed that it becomes necessary to make a section of the ovule to see what goes on in the embryo-sac. In this plant again the fertilization was found to occur precisely as in the preceding species—the progress of the phænomena is here exceedingly rapid. In *Epilobium angustifolium* the embryo was found to be developed in the same manner, but the author could not trace the pollen-tube to the embryo-sac, a section of the ovule being necessary here also.

W. Hofmeister* has published an account of a series of observations on the impregnation of the *Œnothereæ*, his examples being *Godetia quadrivalvum, G. rubicunda, Œnothera longiflora, Œ. Sellowii* and *Boisduvallia concinna*. His results are in perfect accordance with those already noticed as to the real operation of the pollen-tube upon the embryo-sac; he finds that the pollen-tube does push it inwards a little distance in some instances where the embryo-sac is very delicate, in other cases it is itself distorted by the resistance of the embryo-sac.

The first phænomenon which presents itself in the embryo-sac is an accumulation of the protoplasm at the micropyle end of the embryo-sac, and in this we soon find from two to four free cell-nuclei. Round one of these nuclei (cytoblasts) a cell forms, which is the germinal vesicle; a second is next produced, which sometimes divides into two. From one of these the embryo is developed; and that this is the case, and that the end of the pollen-tube does not become the embryo, is the more certain, since at the time of fertilization the pollen-tube and embryo-sac are so firm that they may be separated with a needle under the microscope; the fertilizing matter must therefore pass through three membranes, viz. those of the pollen-tube, of the embryo-sac, and of the germinal vesicle itself.

In *Godetia* traces of the pollen-tube were found even in the ripe seed, and during the progress of the development of the embryo here the pollen-tube *branches* as it lies in the canal of the inner coat of the ovule, while the cellular layer around the embryo-sac has been absorbed, so that the latter with the contained embryo lies free in the ovule.

* Untersuchungen des Vorgangs bei der Befructung der Œnotheren, von W. Hofmeister.—Botanische Zeitung, Nov. 5, 1847.

From the preceding statements we gather the following general statement of the process of impregnation.

At the period of the opening of the flower the embryo-sac exists, and at its upper (micropyle) end one or more cells (germinal vesicles) are produced from cytoblasts. The pollen-tube makes its way down the style into the ovary, and finally through the foramina of the coats of the ovule, and comes in contact with the embryo-sac; here it either applies itself immediately upon the apex or proceeds a little way further, so as to lie rather on the side of the apex of the embryo-sac. Hereupon (and probably as a result of the imbibition of the fluid of the pollen-tube through the membranes) the cell, or one of them if there are more, lying in the embryo-sac, begins to develope, and in course of time produces the embryo.

We may glance at the evidence to be obtained from the accounts given by authors who deduce conclusions different from the above. Meyen* believed that the phænomena presented themselves with two modifications; the first where the embryo-sac evidently exists before impregnation, and the second where, as he believed, this is wanting at that period. The latter modification, where he said that the germinal vesicle is produced by the end of the pollen-tube, cannot be brought into relation with the theory under examination, but the latter presents some points of resemblance. In this case he stated that the pollen-tube comes in contact with the embryo-sac and becomes united with it, and then the germinal vesicle makes its appearance in the embryo-sac. But in one instance which he figured, namely in *Mesembryanthemum glomeratum*†, he confessed that the absorption of the membranes separating the cavities of the pollen-tube and embryo-sac was an assumption, and the figure in question exactly resembles Müller's representation of the phænomenon, the pollen-tube lying rather to the side of the summit of the embryo-sac. If we could believe that he was mistaken in supposing that an actual union of the embryo-sac and pollen-tube took place (and in such investigations graver errors are easily fallen into), the only point of difference would be with regard to the period when the germinal vesicle is first produced.

In reference to Schleiden's opinions, the view which he first promulgated was that the pollen-tube pushed the summit of the embryo-sac before it and became invested by it, but in the last edition of his 'Grundzüge‡', he admits the possibility in certain cases of the actual entrance of the pollen-tube into the embryo-

* Pflanzen-physiologie, vol. iii.

† *Op. cit.* vol. iii. pl. xiii. figs. 46, 47.

‡ Grundz. des Wiss. Botanik, 2nd edit. ii. 366.

sac, in the manner which is described by Gelesnow*; and the figures to his own memoirs do not always show the depression of the summit of the embryo-sac, but exactly resemble the condition which is figured by Müller from *Monotropa* and *Begonia*, where the pollen-tube is applied upon the apex of the embryo-sac and lies in a line with the embryo. Here his statement, that he has drawn out the pollen-tube from the embryo-sac, with the embryo at its extremity, must be set against Hofmeister's affirmation that he has detached the pollen-tube from the apex of the embryo-sac without disturbing the germinal vesicle.

Finally, the whole question now appears to be narrowed to the determination of the point, whether the germinal vesicle does actually exist before impregnation, since if that can be proved, all appearances yet observed may be reconciled, by allowing for very slight errors in interpreting and delineating them. Amici does not express himself very distinctly on this point, but the other three papers which have just been investigated, added to the opinions of Brongniart† and Mirbel‡, will probably satisfy many upon this point.

P.S.—Since the above was written I have found that L. R. Tulasne§ has given a brief *résumé* of some researches into the embryogeny of *Veronica hederæfolia*, *triphyllos* and *præcox*. According to his statements, the pollen-tube here actually perforates the embryo-sac and lies within it; the end of the pollen-tube becomes the embryo and at no period can any *germinal vesicle* be distinguished. These observations therefore go to support the modified views of Schleiden, but until they are more distinctly detailed by their author, their true value can hardly be estimated.

VI.—*Additions to the Fauna of Ireland*||. By William Thompson, Esq., Pres. Nat. Hist. and Phil. Society of Belfast.

Aves.

Bridled Guillemot, *Uria leucophthalmos*, Faber.
—— *lacrymans*, Valenc., Gould, Yarrell.

A communication from Richard Chute, Esq., of Blennerville, county of Kerry, dated Feb. 26, 1846, informed me of his having once shot this bird at Dingle.

* Botanisch. Zeitung, i. 841.
† Mem. sur la génération de l'embryon, &c., Paris, 1827.
‡ Ann. des Sc. Nat. 2e sér. xi. 200 and 381.
§ Comptes Rendus, June 14, 1847.
|| This short communication was intended to be supplementary to two papers on the same subject in the 20th volume, but was too late in being forwarded for that purpose.